11B Lab 6: Ray Optics

Activities Quick List:

1.) Pinhole Camera
2.) Object/image distance
3.) Compound Microscope
4.) Calibrate the isight camera
5.) Microscope sphere measurement

Objectives:

1.) How to produce a real image via pinhole
2.) Pinhole size and how it changes clarity vs intensity
3.) Producing magnified images
4.) Measuring the focal length of a lens
5.) Understand the relationship between do, di, and f
6.) Calculate magnification based on the object to image distance ratio, or using the object to image height ratio
7.) Use a lens to produce a real image, and then a second lens to view this image

Warm-up:

Pinhole Camera:

The box provided has a screen on one side and a pinhole on the other. Face the pinhole towards the light source and adjust the location of the box so you can see an image of the illuminated object.

Questions:

1.) When you look at the screen what are you looking at? (Hint: Are you looking directly at the object? Discuss with your TF)
2.) Is the image upright or inverted?
3.) What happens to the image height when you adjust the distance from the light source?
4.) Draw a simple ray diagram to help illustrate what we are looking at?
5.) Find a spacing between the light source and the pinhole camera so that you get an image that is twice the size of the object. What is the image distance? What is the object distance?
6.) What happens if we increase the size of the pinhole? Try increasing the pinhole by small increments (use a pencil) and observe what happens to the image?
7.) Draw a second ray diagram to account for a change to a large pinhole
8.) What is the benefit to a larger pinhole, and what is the drawback? (Hint: Think about image focus verses image intensity. Discuss with your TF)

Ray Optics Lab:

1.) Measuring the focal length of a lens

A.) Measure the focal length of a lens by looking at an object at "infinity". Our object will be the light bulb at the front of the room.

The focal length of our lens is = _____ meters

B.) Draw a ray diagram of what is happening with the lens. We will assume that the rays of light coming into the lens are coming from "infinity" so that it enters the lens parallel.

2.) Playing with the object and image distances

Take a moment to play with the following ray tracing applet:

[Ray Tracing Applet]

A.) Place the lens on the table next to a two meter stick. Move the illuminated object to a distance away from the lens (do = object distance). Use a screen to find the image that the lens creates (di = image distance). Note that there is a minimum distance that the object can be from the lens to produce this "real image".

What was the minimum distance found to create an image on a screen?

B.) Make a table for 8 different object distances and their corresponding image distances. Choose a range of image distances that are close to the lens as well as far. Also make note of your object height and measure the image height at these same locations. Plot the object vs. image distance results in Matlab with the object distances as you independent variable. Include this graph here with labels and title.

C.) This graph does not look very linear. Can you find some manipulation of the variables that creates a linear plot? Use the basic curve fitting tool to fit this and find the line equation. Include this graph here with labels and title. Also include the equation for the line.

D.) Use the graph to calculate the focal length of the lens and compare this to what you got in the first part. Show your work and comment.

E.) Write down a relationship between the object and image distances that also relates the image and object height? Make a sketch of the situation. Use your data from part B explain what you have found.

F.) Define image magnification in terms of image and object heights. Both in words and with an equation. For a single lens. Discuss with your TF.

3.) Make a Compound Microscope on the Desktop

A.) There is an example of small print text on the table. Looking through a single lens, make the text appear as large as possible to your eye. How close is the lens to the object when this occurs? Is the image right-side-up? Describe what you observe

B.) Set up a single lens system so that you project a magnified image of the small text on the translucent screen. This is the real image for your "microscope".

C. With the translucent screen still in place, use a second lens to give you the best possible (most enlarged) view of this image.

D. Continuing to view the image, have your partner remove the screen. This is how a conventional compound microscope works.

E. Draw a picture.

F. Play around to get even more magnification.

G. We have been discussing "real" images. Describe in one sentence a property or properties that is/are shared in common by these images (think in terms of location of light). Discuss with your TF.

4.) Calibrate Your Isight Camera

A.) Place the lens between the isight camera and the illuminated graph paper. Use Logger Pro to view the image recorded on the CCD array in the camera. In the Logger Pro menu items choose "Insert" => "Video Capture" => "400x300"

B.) Arrange the do and di so that you can see the image being projected onto the CCD of the camera. Is the image larger or smaller than the object in this arrangement?

C.) Using the Logger Pro measurement tool we can find out how many pixels wide our image is.

D.) Use what you know about the current set-up to determine the size of a single pixel. The CCD is set back from the front of the camera by 23mm. Show your work with the help of a diagram.

5.) Latex spheres under a microscope

A.) Challenge: Use the microscope at your table to view some latex spheres with the Isight camera. Can you figure out how large the spheres really are? The distance between the object and the lens is only about 4.5 mm. Explain your procedure.